PAN-PACIFIC ENTOMOLOGIST
70(3): 212–221, (1994)

NEUROPTEROIDEA FROM MOUNT ST. HELENS AND MOUNT RAINIER: DISPERSAL AND IMMIGRATION IN VOLCANIC LANDSCAPES

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Abstract.—Neuroptera (= Planipennia) and Raphidioptera were collected from barren, unvegetated habitats at Mount St. Helens following the 1980 eruption and from summer snowfields in the alpine zone on Mount Rainier. A total of 291 specimens were taken in pitfall or flight traps at Mount St. Helens or hand collected from snowfields on Mount Rainier. The data represent individuals engaged in long distance dispersal flight as opposed to local, within habitat movement. Phenological patterns of dispersal are detailed for species and evidence is presented for female sex bias of dispersers for several species.

Taxa in four families are represented: 24 specimens of Coniopterygidae (*Coniopteryx* sp., *Conwentzia californica* Meinander, *Semidalis* sp.); 219 Hemerobiidae (*Hemerobius bistrigatus* Currie, *H. humulinus* Linnaeus, *H. kokeeanus* Currie, *H. neadelphus* Gurney, *H. pacificus* Banks, *H. simulans* Walker, *H. stigma* Stephens, *Micromus borealis* Klimaszewski & Kevan, *M. variolosus* Hagen, *Wesmaelius involutus* (Carpenter), *W. longifrons* (Walker), *W. nervosus* (Fabricius), *W. pretiosus* (Banks)); 44 Chrysopidae (*Chrysopa coloradensis* Banks, *C. nigricornis* Burmeister, *C. oculata* Say, *Chrysoperla carnea* Stephens, *Eremochrysa punctinervis* (McLachlan), *Meleoma dolicharthra* (Navas), *M. emuncta* (Fitch), *Nothochrysa californica* Banks); 4 specimens Raphidiidae (*Agulla adnixa* (Hagen)).

Key Words.—Insecta, Neuroptera, Raphidioptera, Mount St. Helens, Mount Rainier, dispersal, colonization, phenology

The eruption of Mount St. Helens in May 1980 devastated at least 600 km^2. In an area immediately north of the volcano, now called the Pumice Plain, the biota was completely removed. That area, comprising more than 50 km^2 of bare mineral surface, provided sites on which the immigration of arthropods could be monitored in the complete absence of local populations.

We report here the diversity and aspects of the phenology of Neuropteroidea, mainly Neuroptera (= Planipennia) but including some Raphidioptera, collected on or in the vicinity of Mount St. Helens and an adjacent Cascade volcano, Mount Rainier. The collections from Mount St. Helens were part of surveys documenting patterns of survival and recovery of arthropod populations in the area of the volcano following the 1980 eruption. We focus on material taken in the first several years following the eruption from sampling sites in the Pumice Plain which lay at least 3 km from potential source habitats and at least 10 km from relatively undisturbed source areas. This material, therefore, reflects long distance dispersal rather than local movement of individuals. A few records are from sites where some residual vegetation survived. We include data from collections made from alpine snowfields on Mount Rainier, which also indicate long distance dispersal.

The Neuroptera as a whole were a minor component of the samples taken in arrays of pitfall and flight traps at Mount St. Helens, and they were not among the first colonists (predatory and scavenging beetles, primarily carabids, and spiders). Neuroptera nonetheless play a significant role as predators, particularly of homopterans like aphids, and the data presented here imply a steady source of immigrants to incipient populations as the devastated area becomes vegetated.

Little has been published on the Neuropteroidea of the Pacific Northwest. The only faunal survey listing species is from long term ecological work on the H. J. Andrews Experimental Forest in the Cascade Mountains of Oregon (Parsons et al. 1991). We add here a number of taxa to the list for Cascade Neuroptera, including a number of new records for the area. Our list is also unique in that the captures represent individuals all engaged in a biologically critical activity, namely dispersal.

Study Area

The most severe impact of the eruption occurred north of Mount St. Helens, between the volcano and Spirit Lake, an area now called the Pumice Plain (Figs. 1 and 2a), and some distance down the Toutle River to the west. In this area virtually all surfaces were buried by landslide deposits, covered by pyroclastic surges, with emplacement temperatures of several hundred degrees centigrade, or scoured clean (Christiansen & Peterson 1981). Between 1981 and 1983, three study sites were established in the Pumice Plain with 6 more added by 1985 (Figs. 1 and 2A). The post-eruption surfaces presented a mosaic of pyroclastic flow deposits (ranging from pumice boulders to fine volcanic ash), rock outcrops and landslide debris. Immediately following the eruption there was no emergent vegetation in the area but during this study, a number of plant species colonized the area. However, plants became only locally abundant in a small number of isolated patches (Wood & del Moral 1988). Sites were also established on the southern slopes of the volcano where survival of vegetation was extensive. Site elevations ranged from 1000–1200 m in the Pumice Plain to 1300–1500 m for sites on the southern slopes of Mount St. Helens.

Southwest winds predominate throughout the annual April–October sampling period. Brief sequences of days with easterly winds, alternating with westerlies, become more frequent and prolonged in September and October. Westerly surface winds reach the sampling sites via the agricultural Puget lowland, forested Toutle River valleys, and volcano-impacted mudflow and blowdown areas. Summer air temperatures rarely exceed 25° C. Maximum surface temperatures at the sampling sites are generally in the range 40–50° C. Summer rainfall can vary greatly; most precipitation occurs October through April and summers are generally dry. In 1983 rainfall was abundant while exceptional drought conditions prevailed in 1984.

Mount Rainier is located approximately 80 km to the north of Mount St. Helens (Figs. 1 and 2B). Samples were taken from snowfields ranging in elevation from about 2200 m to the volcano summit (4392 m).

Materials and Methods

Sampling Method.—At Mount St. Helens, arthropods were sampled using pitfall traps and flight traps made of 30 cm × 60 cm sheets of plexiglass suspended over a bucket containing a 50% solution of ethylene glycol based anti-freeze. Some hand collecting was also done.

Pitfall traps were plastic cups (Lilylite 9 oz. tumblers) which set snugly in 7.6

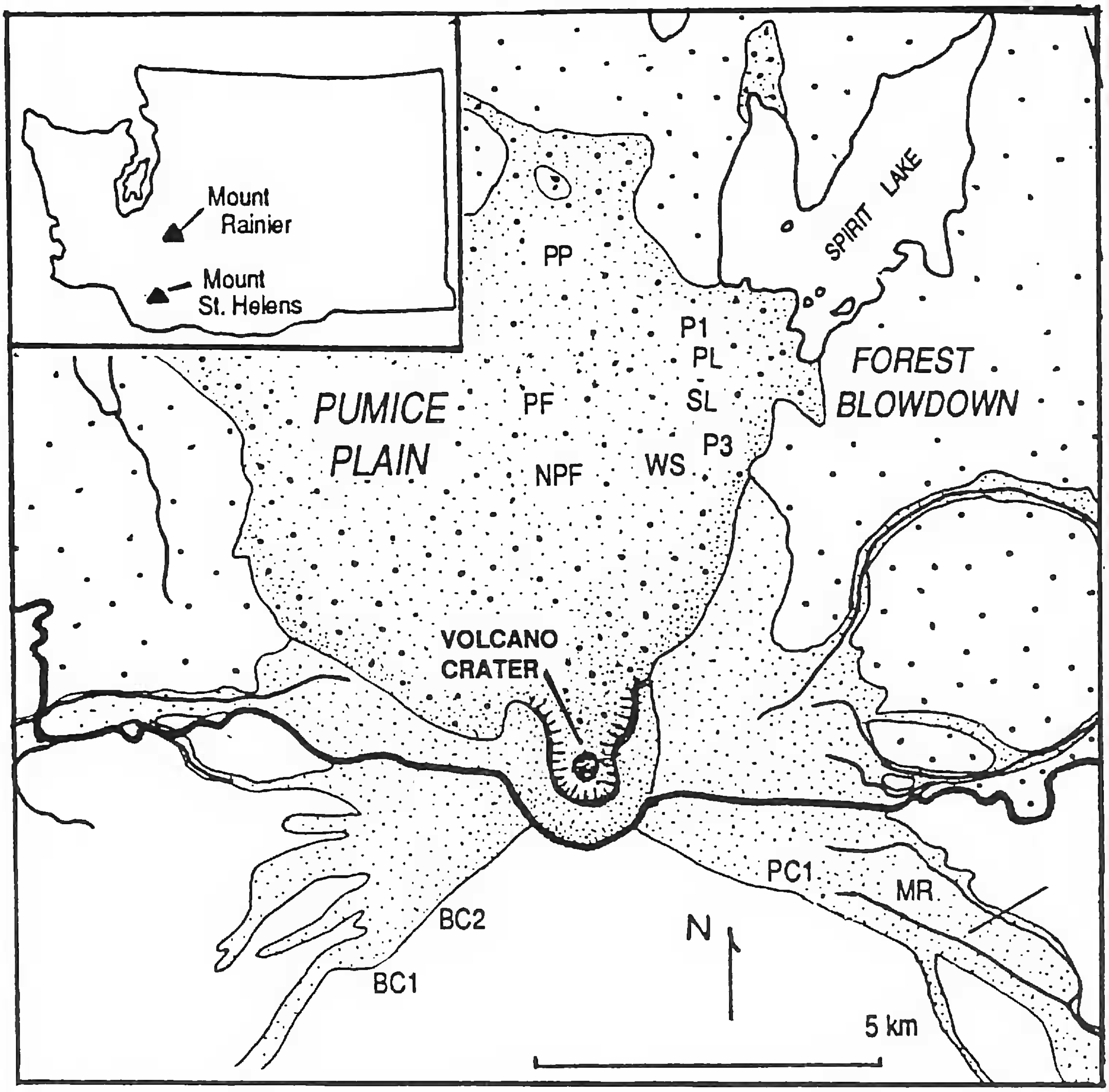

Figure 1. Map of the devastated area of Mount St. Helens showing location of sampling sites in the Pumice Plain and on the volcano. Inset shows location of Mount St. Helens and Mount Rainier in Washington State.

cm diameter plastic (PVC) pipe sections set in the ground. The PVC sleeve allowed swift change of cups without disturbing the surrounding ground surface. Pitfalls were partially filled with a 2:1 solution of antifreeze and water which served as a killing agent and preservative, and were protected from rain and disturbance by a square piece of plywood supported approximately 2 cm over the trap. From 5 to 26 pitfalls were set at each site. Pitfalls were generally collected at two week intervals. Sampling periods at sites ranged from 5 weeks to 30 weeks of continuous sampling. Some specimens were collected from overwinter samples where pitfalls were left in place and collected the following spring. Since snowpack tended to press the pitfall cover down, effectively closing the pitfall, these samples probably represent individuals caught in the fall, after mid-October but before significant snowfall.

At Mount Rainier collections were made from 2 × 100 m transects on snowfield

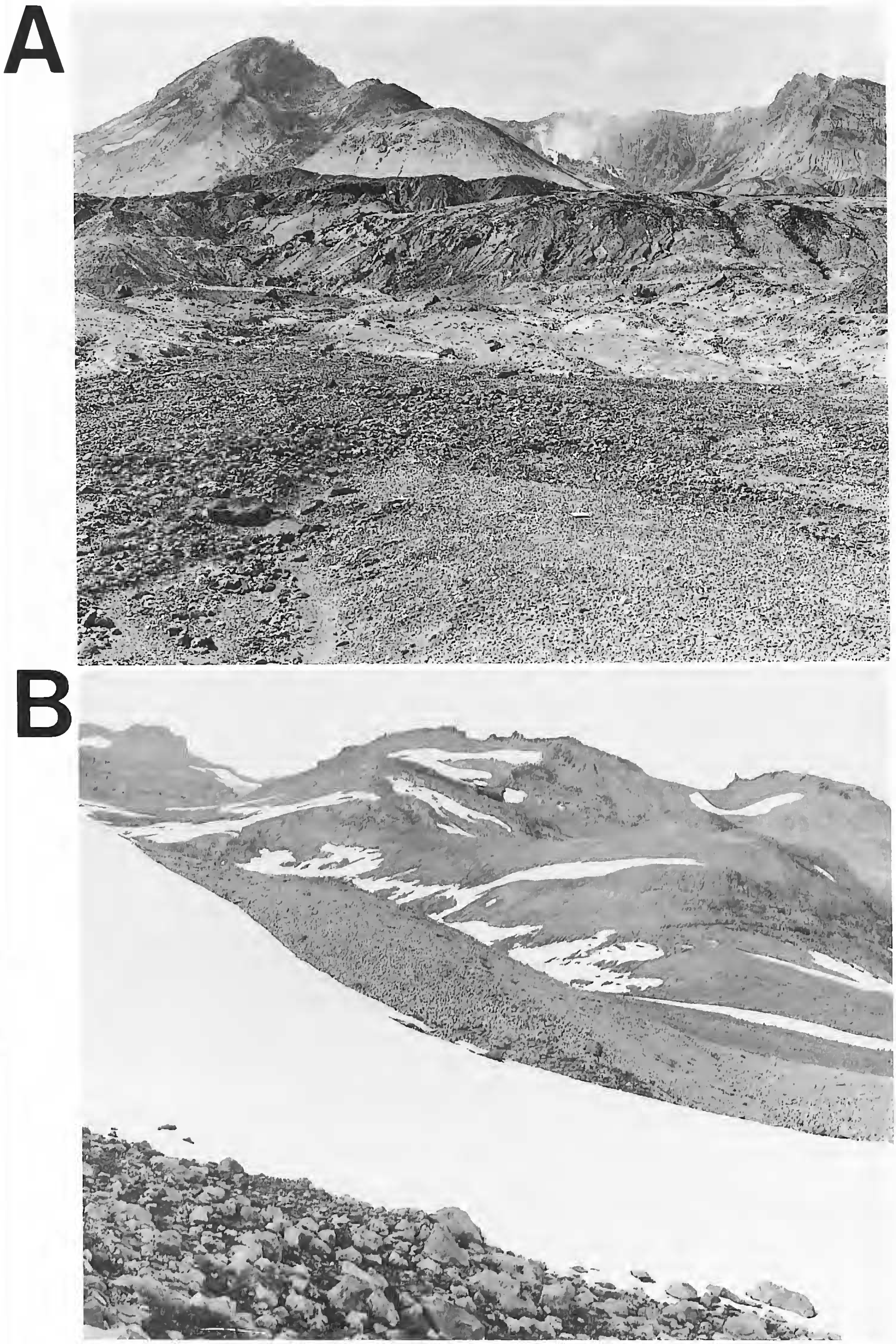

Figure 2. A.) View of the Pumice Plain of Mount St. Helens in 1984. B.) View of snowfield (elevation 2500 m) on Mount Rainier.

sites at elevations ranging from 2200 to over 4000 m. Hand collections were also made at various locations including the summit crater. Collections were made from mid-May to mid-October with most in early to mid-July at elevations between 2400 and 3000 m.

Specimens were stored in alcohol until identified to species by one of us (LG). Confirmation on identification of several taxa was made by several others (noted in Acknowledgment). Voucher specimens are stored at the Thomas Burke Memorial Museum, University of Washington, Seattle, Washington.

A phenogram was assembled from original collection data, mainly from pitfall traps, taken over several years, each year with a different set of sampling dates. Sampling periods varied but were generally from 10–14 days. Collection dates for samples were standardized by dividing the season from May to October into 10 day intervals, assigning each sample to the 10 day interval in which the midpoint of the sampling period fell.

Results

Diversity.—A total of 250 specimens from 23 species were collected in traps at Mount St. Helens from 1981 to 1986. Another 41 specimens from 10 species were collected from snowfields on Mount Rainier from 1975 to 1976. This presents a total of 291 specimens representing 25 species from 12 genera in four families (Table 1).

Phenology.—Consistent with previous findings of adult activity for most Neuroptera, adults of most taxa were active from spring to fall (Fig. 3). Peak activity, as indicated by captures, varied among taxa. The coniopterygid *Conwentzia californica* Meinander was present from spring through fall but the majority of captures occurred from mid-summer to fall (Fig. 4A). For most hemerobiids the capture rate increased through the season with a peak in late summer-early fall. An exception was *Wesmaelius involutus* (Carpenter). It was abundant in early summer but absent in our fall samples (Fig. 4D). Several species of *Hemerobius* were active from spring to fall with a general increase in numbers of dispersers through the season (Fig. 4E–I). Taken as a whole, there were 3 peaks in the number of *Hemerobius* dispersers through the season, with an increase in number for each successive peak (Fig. 4I). The chrysopids as a group are similar to the *Hemerobius* spp. in having the greatest numbers of dispersers in late summer-early fall (Figs. 3 and 4). *Chrysoperla carnea* Stephens, the only chrysopid caught in any number, had a major dispersal period from September–October.

Sex Ratios.—A Chi-square goodness of fit test (Zar 1974) on the 6 taxa with 10 or more total individuals in which males and females were identifiable revealed 3 cases where females were significantly more common than males, the coniopterygid *Conwentzia californica* and the hemerobiids *Micromus variolosus* (Hagen) and *Hemerobius stigma* Stephens (Table 1). Among species of *Hemerobius,* if *H. stigma* is subtracted from the rest, there is still a female bias (53 males : 63 females), but it is not significant. There is bias in species of *Wesmaelius* taken as a whole (total 8 males : 15 females), but it is not significant. In contrast, the chrysopids (22 males : 20 females) show no indication of a shift from a 1:1 sex ratio. All specimens of the snakefly *Agulla adnixa* (Hagen) were female but the small number found (4) precludes analyses.

Table 1. List of species and numbers of individuals from families of Neuropteroidea from Mount St. Helens (MSH) and Mount Rainier (MR). Numbers of males and females shown if known (males: females) and individuals with abdomens missing shown in parentheses. Significant deviations ($P < 0.05$) from 1:1 in sex ratio noted with asterisks. Total for Neuroptera: 4 families, 12 genera, 24 species (110 males, 172 females, 9 specimens); Raphidioptera: 1 family, 1 genus, 1 species.

Family	Species	Numbers (males: females)		
		MSH	MR	Total
Coniopterygidae	*Coniopteryx* sp.	–:1	—	–:1
	Conwentzia californica Meinander	3:18	—	3:18*
	Semidalis sp.	–:1	—	–:1
Hemerobiidae	*Micromus borealis* Klimaszewski & Kevan	1:1	—	1:1
	M. variolosus Hagen	4:14	–:2	4:16*
	Wesmaelius involutus (Carpenter)	6:8	—	6:8
	W. longifrons (Walker)	2:5	—	2:5
	W. nervosus (Fabricius)	–:1	—	–:1
	W. pretiosus (Banks)	–:1	–:1	–:2
	Wesmaelius sp.	–:1 (1)	—	–:1 (1)
	Hemerobius bistrigatus Currie	6:3	1:–	7:3
	H. humulinus Linnaeus	1:–	—	1:–
	H. kokaneeanus Currie	5:2	—	5:2
	H. neadelphus Gurney	26:13[a] (2)	3:-x	29:13[a] (2)
	H. pacificus Banks	9:-x	1:-x	10:x
	H. simulans Walker	1:–	—	1:–
	H. stigma Stephens	14:26	4:8	18:34*
	Hemerobius sp., females[b]	37	8	45
Chrysopidae	*Meleoma dolicharthra* (Navas)	2:1	1:2	3:2
	M. emuncta (Fitch)	–:1	—	–:1
	Chrysopa coloradensis Banks	1:–	—	1:–
	C. nigricornis Burmeister	1:1	—	1:1
	C. oculata Say	–:1	—	–:1
	Chrysoperla carnea Stephens	14:13 (1)	1:1	15:14 (1)
	Eremochrysa punctinervis (McLachlan)	–:1	—	–:1
	Nothochrysa californica Banks	—	2:1 (1)	2:1 (1)
Raphidiidae	*Agulla adnixa* (Hagen)	—	(4)	4

[a] 13 females are tentatively placed here. Females cannot be determined with certainty. Criterion for assignment of females here was presence of males and absence of male *H. pacificus* in the same sample.
[b] Most females are probably *H. neadelphus* or *H. pacificus.*

Discussion

Diversity and Dispersal.—Previous sampling of Neuropteroidea in the Cascade Mountains of Oregon recorded 17 species of Neuroptera and 5 species of Raphidioptera (Parsons et al. 1991). Our sampling adds 11 taxa to the list of Cascade Neuroptera, including several new records for the region or for Washington State. More importantly, the majority of these records indicate the prevalence of long distance dispersal. Some records (20) come from sites on the southern slopes of Mount St. Helens (Fig. 1, PC and BCa) where there was some local survival of vegetation and the possibility that these records represent local movement cannot be discounted. We include them because in nearly every case the time of capture coincides with capture of individuals in the non-vegetated habitats of the Pumice Plain of Mount St. Helens or the snowfields of Mount Rainier. For *M. variolosus* they add significantly to the total number of records (7 of 20 for that species).

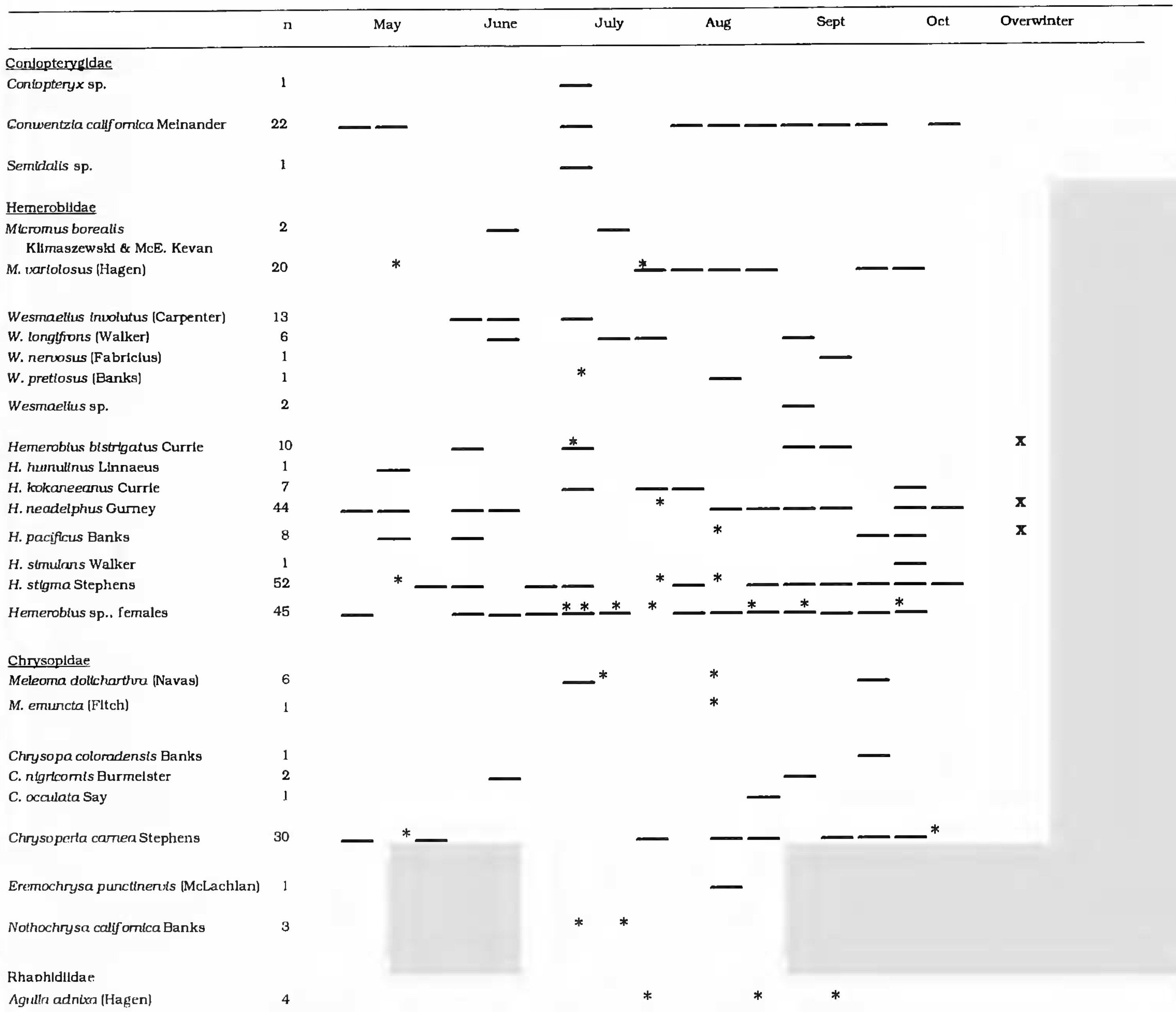

Figure 3. Phenological pattern showing periods in which neuropteran species were caught by traps at Mount St. Helens (solid bars) or hand collected at Mount Rainier (asterisks). Overwinter samples represent individuals caught in traps from late October on, and not collected until the following spring.

Long distance dispersal is not effected solely by the active flight of individuals; wind currents play a major role in the distribution of dispersers (Johnson 1969). Our data on Neuropteroidea do not allow for a distinction between active flight and passive carriage on the wind, but the high incidence of ballooning spiders among the arrivals at the sampling sites (Crawford & Edwards 1986) suggests that prevailing winds from the southwest may also play a part in the distribution of Neuroptera.

Female Dispersal Bias.—We suggest that the difference in numbers for those species with significant female bias has biological significance and reflects a tendency for females rather than males to undergo long distance dispersal. Another possibility is that the significant female bias is a reflection of the primary sex ratio for these species, although divergence from a 1:1 sex ratio is rare and should occur only under special circumstances (Hamilton 1967). We doubt the other alternate explanation, that the sex ratio is a reflection of behavior, with females more likely to be caught in traps than males. For *H. stigma* the same bias is seen from collections on snowfields of Mount Rainier (4 males : 8 females) as is found for individuals trapped at Mount St. Helens (14 males : 26 females), and the snowfields should retain individuals regardless of sex.

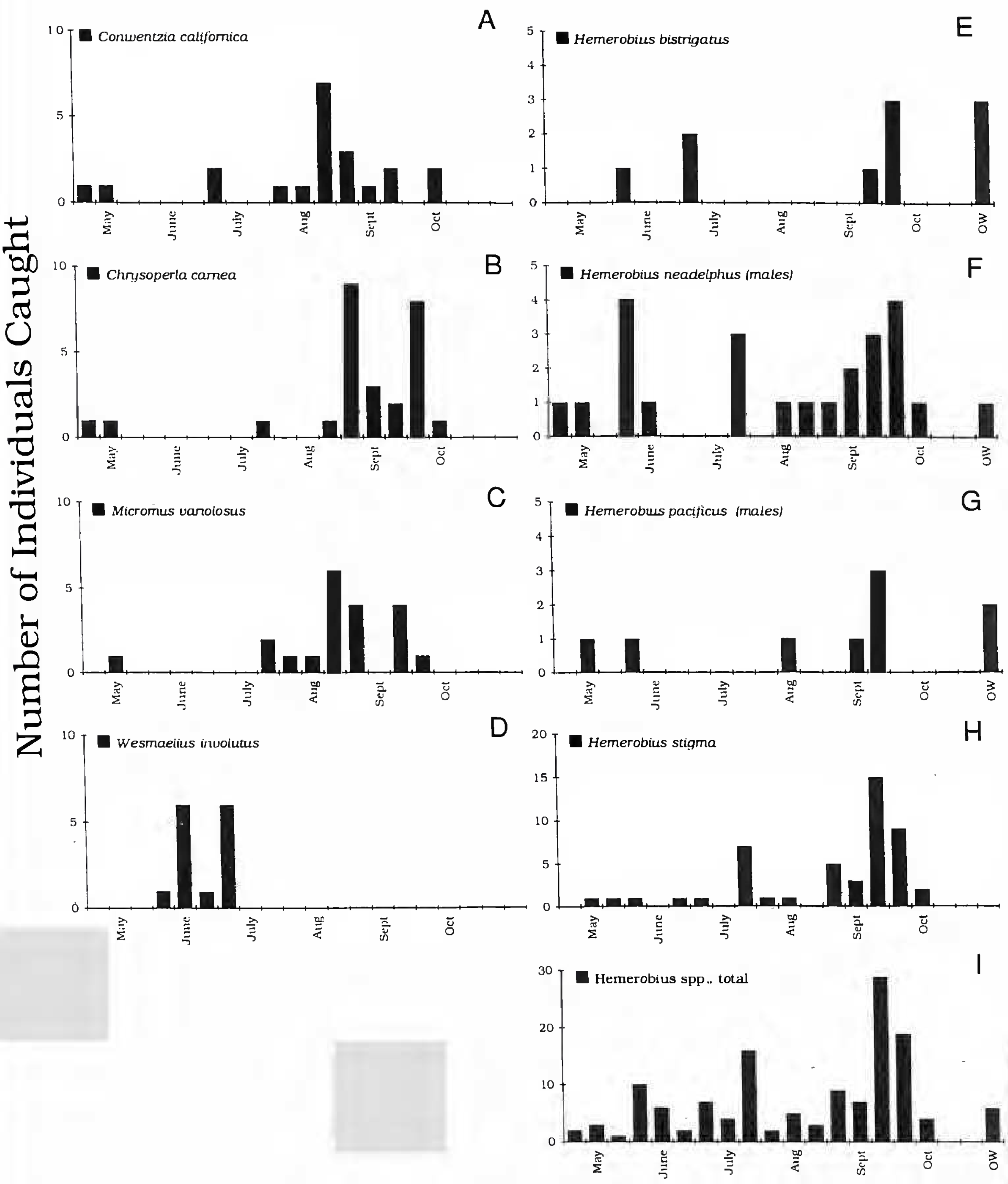

Figure 4. Phenology of select Neuroptera taxa found at Mount St. Helens. Results show number of pitfall or flight trap captures occurring in 10 day time periods from 1981–1985. The results for *Hemerobius neadelphus* and *H. pacificus* are shown for males only because females cannot be reliably identified.

Vegetation Association.—Vegetation data are sparse for many neuropteran taxa. In many cases the published records for a species are mainly from crop plants but the ecological breadth of most species is undoubtedly wider. For example, Meinander (1972) recorded *C. californica* from citrus trees and cherries but the Mount St. Helens records indicate association with a broader spectrum of vegetation. We do not know from where our samples originated but the vegetation of habitats near our sampling sites is dominated by conifers with stream drainages including hardwoods such as alder, willows and maple. Openings along rivers, roads and clearcuts provided habitats dominated by shrubs and herbs. Hemerobiid larvae were common in pitfall traps near herbaceous vegetation (mainly fireweed, *Epilobium angustifolium* (L.)) of clearcut areas in the devastated area of Mount St. Helens but none were reared to adult so the species are not known.

Miscellaneous Notes on Select Taxa.—Our data provides new information on several of the taxa collected including extensions of the recorded seasonal activity or range.

Conwentzia californica. Meinander (1972) records adults from March through August; our data indicates dispersal activity into October.

Semidalis sp. Females of most *Semidalis* species cannot currently be identified to species (Meinander 1972). Ours may represent the first record of the genus from Washington State.

Micromus borealis Klimaszewski & Kevan. Ours represent the first records from the lower 48 states.

Micromus variolosus Hagen. *M. variolosus* was the most common neuropteran found at sites on the southern slopes of Mount St. Helens. Our samples had a significant female bias (Table 1).

Wesmaelius involutus (Carpenter). *W. involutus* contrasts with all other taxa for which we have reasonable numbers in our samples in having a peak dispersal activity period in the early summer (Fig. 4D).

Wesmaelius nervosus (Fabricius). This is the first record known to us from the western U.S.A.

Wesmaelius pretiosus (Banks). This is apparently the first record from Washington State.

Hemerobius spp. Numbers for individual species suggest periods of dispersal which may correlate with brood cycles. If species totals are combined, there are three clear peaks in dispersal, late spring, mid-summer, and late summer-early fall (Fig. 4I). This suggests three brood cycles annually in this area.

Hemerobius bistrigatus Currie. Before this study, adults were known from March to September (Kevan & Klimaszewski 1987). Most of our records are from September and October, but a few individuals were caught in early June or July.

Hemerobius neadelphus Gurney. Mitchell (1962) considered three generations per year to be possible even at high elevations. The data presented here (Fig. 4F) also suggest three generations.

Acknowledgment

We thank P. A. Adams, U. Aspöck, J. Klimaszewski, and M. Meinander for their assistance in identifying our samples. We also acknowledge the late D. K. McE. Kevan for assistance and advice. C. A. Tauber gave helpful comments and suggestions on an early draft. P. C. Banko, C. B. Becker, R. I. Gara, D. Mann and M. Peterson assisted with collecting and processing samples. U.S. Forest Service personnel from Randle and St. Helens Districts, Gifford Pinchot National Forest and those of Mount Rainier National Park were helpful in the course of the field work. This work was supported by NSF Grants DEB 80-21460, DEB 81-0742 and BSR 84-07213; LG was provided support by University of Bergen.

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